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Round Table

Landmines and UXO

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Problem:

An estimated 11,000,000 acres of land in the United States is potentially contaminated with unexploded ordnance (UXO). Cleanup of these UXO-contaminated lands is a high priority requirement for the Department of Defense (DoD). In spite of years of effort and hundreds of millions of dollars investment, the problem of detecting and mapping buried UXO remains largely unsolved in terms of efficient and reliable technology and approach. Only one of the explanations for the continued lack of solution of the UXO detection requirement is explored in this paper. There is considerable history in the DoD of efforts to lump landmines and UXO into one grouping in terms of efforts to detect and remediate. This grouping of landmines and UXO has led to unfocused, inefficient programs and still no general purpose solution to either of the problems.

Definitions/Scenarios:

Landmines are a form of ordnance. However, landmines are placed on or under the ground (generally very shallow, < 10 cm) in an armed state and designed to explode in the as-placed condition upon encountering a triggering stimulus. The trigger stimulus can be pressure from foot or vehicular traffic or the magnetic or electromagnetic signature of nearby passing vehicles. *Mines are designed to be inherently unsafe in the as-placed condition*. Also, mines are frequently constructed with minimum metal content to avoid detection. Mines are typically circular or rectangular in cross-section and are generally placed with the largest dimensions parallel to the ground surface. Mines are sometimes laid in patterns or along transportation corridors or approach routes or along defensive positions. The greatest requirement for landmine detection and clearance is at non-U.S. locations, where detection and clearance sometimes must be undertaken in the presence of external safety threats.

UXO are ordnance that are fired, launched or dropped and designed to detonate on impact with the ground, at the end of a preset time, or on proximity to a target. The fact that they now exist in a buried state in the ground means that they have malfunctioned--they are duds (an exception to this UXO scenario are those cases where ordnance items were dumped or placed in excavations or trenches). UXO were not designed to be buried in the ground in an unexploded state. UXO can exist at depths from the surface to 7-8 meters. UXO have survived the extreme environments of being fired, launched, high-g impact, and penetration, although the safety status of the buried UXO cannot be stated with any assurance. However, *UXO are ordnance items that were designed to be inherently safe* in a stockpiled/unarmed state. Routine handling of ordnance prior to firing (or dropping in the case of bombs) will not cause detonation. Also, UXO are constructed of metal for strength and durability, with no thought ever of avoiding detection. UXO are almost always streamlined is shape and elongated in one dimension (an axis of symmetry). UXO are buried in virtually any orientation and generally randomly located in impact areas (i.e., no patterns). The primary DoD requirement for UXO detection and remediation is at training ranges and formerly used defense sites at

U.S. locations, although UXO remediation at U.S. bases and training ranges in Europe is also emerging as a requirement. Detection and remediation of UXO can generally occur without external safety concerns.

Detection Considerations:

Ultimately, safe clearance of *landmines* requires a standoff or an unmanned, remote detection capability due to the inherently unsafe nature of landmines. Standoff detection capability can be achieved with both ground-based (booms) and airborne platforms. The fact that landmines exist from the surface to maximum depths of approximately 10 cm makes detection possible with various scanning/imaging geophysical systems, e.g., synthetic aperture radar (SAR) systems, infrared (IR) systems, multi-spectral remote sensing, scanning laser reflectance/ polarization systems. Also, standard ground penetrating radar (GPR) systems and electro-magnetic induction (EMI) systems are applicable to mine detection. Since mines have very small metal content, particularly newer mines that are specifically designed to evade detection, magnetic survey systems have little applicability to general purpose mine detection. It is only because of the very shallow burial of mines that SAR s, IR and multi-spectral systems are applicable to mine detection.

UXO does not in general require standoff detection capability. IR and multi-spectral imaging systems and SAR's are not applicable to general purpose UXO detection. GPR's are not applicable to general purpose UXO detection due to the extremely site-specific depth of investigation capability and other special considerations. Since all UXO contain metals and generally ferrous metals, an integrated combination of magnetic and EMI systems is the preferred approach to UXO detection and mapping. In fact, magnetic surveying, which is not applicable to mine detection, is a primary tool for UXO detection. GPR are most applicable only to special purpose UXO discrimination and identification once the UXO has been located by other methods.

Position:

For purposes of military research and development, landmines and UXO are separate problems: burial scenarios are different; ordnance operational scenarios are different; safety considerations are different; detection technology considerations are different; remediation considerations are different. It follows that (1) detection and remediation of UXO and (2) detection and neutralization of landmines must be treated independently at all levels, or the DOD will continue to use scarce funding in pursuit of ill-advised joint landmine/UXO programs that fail to achieve workable solutions.

Why is this position on the distinction between landmines and UXO important to geoscientists? Characterization of the subsurface and specifically the detection and characterization of localized objects in the subsurface is a problem which should be and is best addressed by geoscientists; in fact, it is what geoscientists do all the time, for various reasons and at all spatial scales. However, there have been few geoscientists involved at any level in planning and managing landmine and UXO detection research and development programs. For the buried UXO problem at least, a rudimental realization is emerging that perhaps geoscientists (and particularly geophysicists) should be involved in developing programs to address the problem. If the buried UXO detection and remediation requirement remains linked to and likely considered a subset of the landmine detection and clearance problem, there is considerably less likelihood that geoscientists will have significant input to planning and management of programs due to the traditional, strongly entrenched mine clearance and de-mining approaches and chain of command turf in DoD.

Reference: *The Leading Edge*, **16**(10), p. 1460.